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SOME PLANTS OF IMPORTANCE IN POND- FISH CULTURE

By EMMELINE MOORE, PH. D.

APPENDIX IV TO THE REPORT OF THE U. S. COMMISSIONER
OF FISHERIES FOR 1919



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SOME PLANTS OF IMPORTANCE IN POND FISH CULTURE.

By EMMELINE MOORE, *Ph. D.*

Contribution from the U. S. Fisheries Biological Station, Fairport, Iowa.

INTRODUCTION.

It is a matter of importance in the production of pond fish to control the growth of aquatic vegetation. This can not profitably be done until it is known what plants enter directly into the fish dietary or contribute indirectly to the support of the various animal forms upon which fish feed.

There is little precise knowledge of the natural food of the advanced fry and young fingerlings of our ponds and streams. Nearly all of the examinations of the food content of fishes refer to the advanced fingerling stages or to adults. The importance from an economic standpoint of securing information about the natural forage of very young fish is seen at once. So far as we know, only a small percentage of the fry reach maturity, and by more or less vague explanations the failure has been referable to our lack of knowledge of the food relations in their environment.

This investigation, conducted at the U. S. Fisheries Biological Laboratory, Fairport, Iowa, refers primarily to the aquatic vegetation in the food of fish which are reared in ponds and considers the problem from the following standpoints: What plants contribute directly to the food of the advanced fry and fingerlings? What plants contribute indirectly to their food by providing forage for the various animal forms upon which fish feed? The investigation covers the period of the summer months during two seasons, June 20 to August 31, 1917 and 1918.

The data presented illustrate the dependence of the young fish on food, mostly animals, which in turn feed on plants. The determination of these plants, which are the basic source of the food supply in the ponds, forms the chief contribution of this paper. Numerous examinations have been made of the food content of young fish, in which the direct use of plants by them is revealed. The results have been formulated into tables (p. 14) which supplement the data already at hand in the researches of Forbes (1880), Pearse (1918), Reighard (1915), and others, and indicate plant values among the flowering plants, the filamentous algæ, and various microscopic plants.

The method pursued has been to study the plant population and, correlatively, the contents of the digestive tract in various species of

young fish. An inventory (Table 1) was taken of the plant population in certain ponds,^a covering all forms, the larger rooted aquatics, the floating forms, including the filamentous algae, and the plankton. Simultaneously with the inventory an examination was made of the food found in the digestive tracts of the young fish taken from the ponds at regular intervals. By this means it has been possible not only to identify the food but to determine the character of the forage grounds of the fish and to consider the various plants and the animal associations of importance in the economy of the pond.

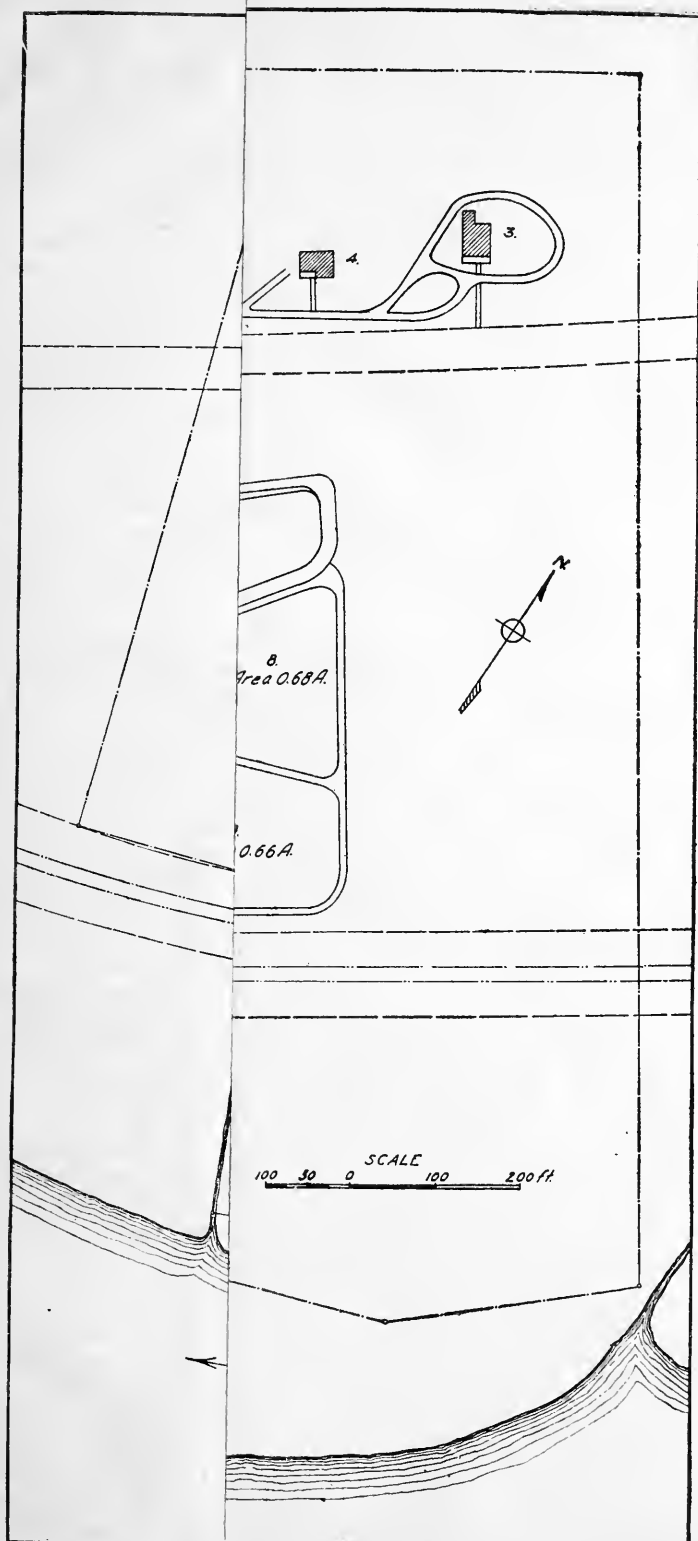
Collections of fish were made at weekly intervals and, if not examined at once in their fresh condition, were kept in an alcohol-formalin preserving fluid until needed. In examining the food the method of Pearse (1918) was employed, that is, the food content of the digestive tract was pressed out upon a glass slide, moistened, and examined under the dissecting and compound microscopes. All figures in the tables referring to food content represent volumetric percentage estimates. Measurements in lengths are given in millimeters and exclude the caudal fin.

A brief and general description of the ponds under investigation will assist in making the interpretation. The accompanying map from an earlier publication of the Bureau shows clearly the position and arrangement of the ponds at the Fairport station. They are grouped in six series, A, B, C, D, E, and F, respectively, the ponds in each series being numbered independently. The investigations here recorded were concerned only with series B and D, the former composed of six small, the latter of nine somewhat larger dirt ponds. The areas of the specific ponds studied, that is, 16B and 1, 2, 3, 8, and 9D, vary from 0.22 to 0.85 acre. Water is supplied to each through inlet pipes connected with a large reservoir, which in turn is supplied from the Mississippi River. The depth varies from about 6 inches near the inlet pipes to 7 or 8 feet at the outlet. Plants common to the ponds of the region have been introduced; marsh plants such as cat-tails, *Sagittaria*, *Bidens*, and *Eleocharis* occupy the shallower portions; sedges bind the borders of the deeper portions; and floating and rooted aquatics flourish within the pond area. Various aquatic insects and other animal forms have found their way into the ponds, and practically natural conditions prevail.

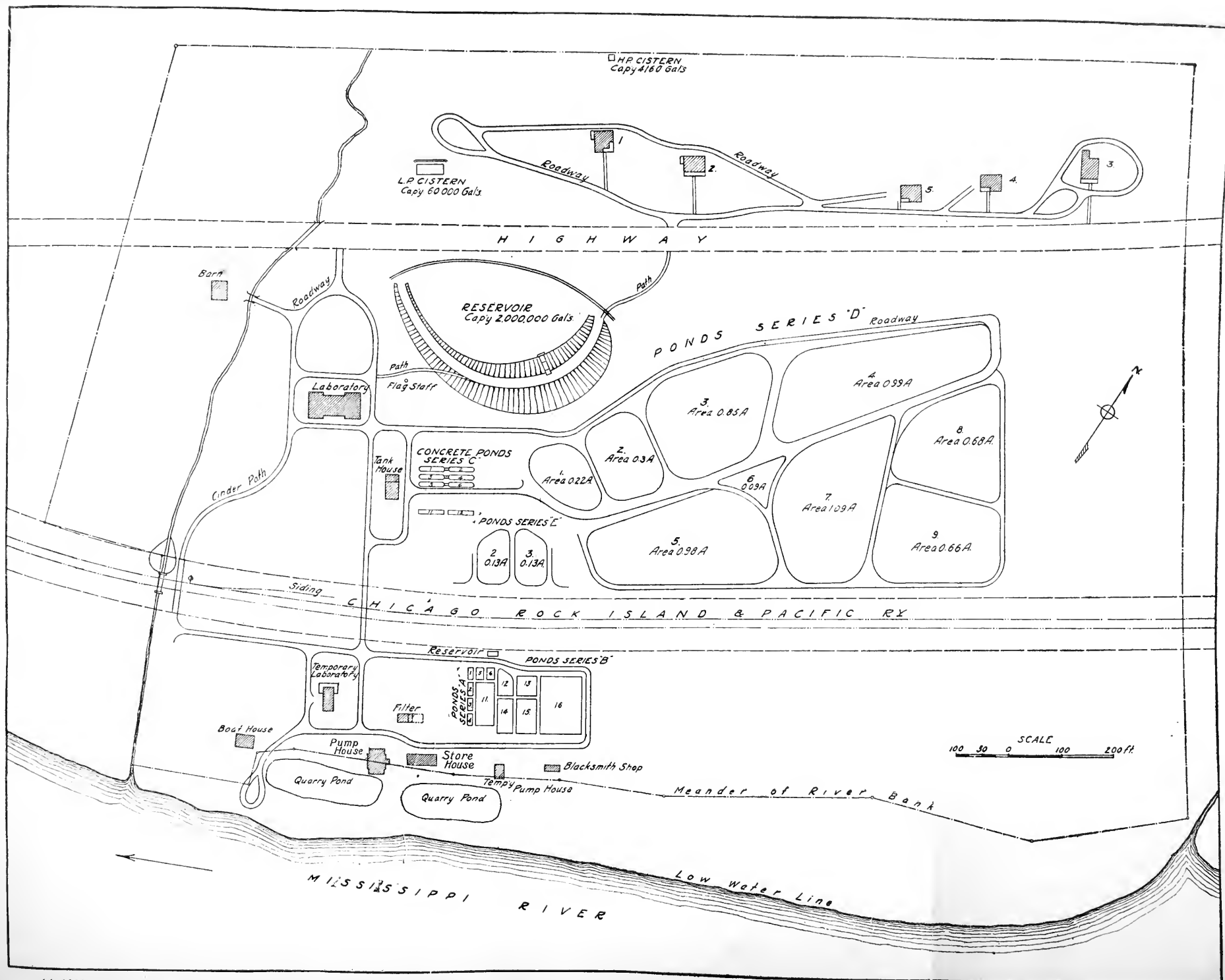
BASS, CHIRONOMID, AND ALGAL RELATIONS.

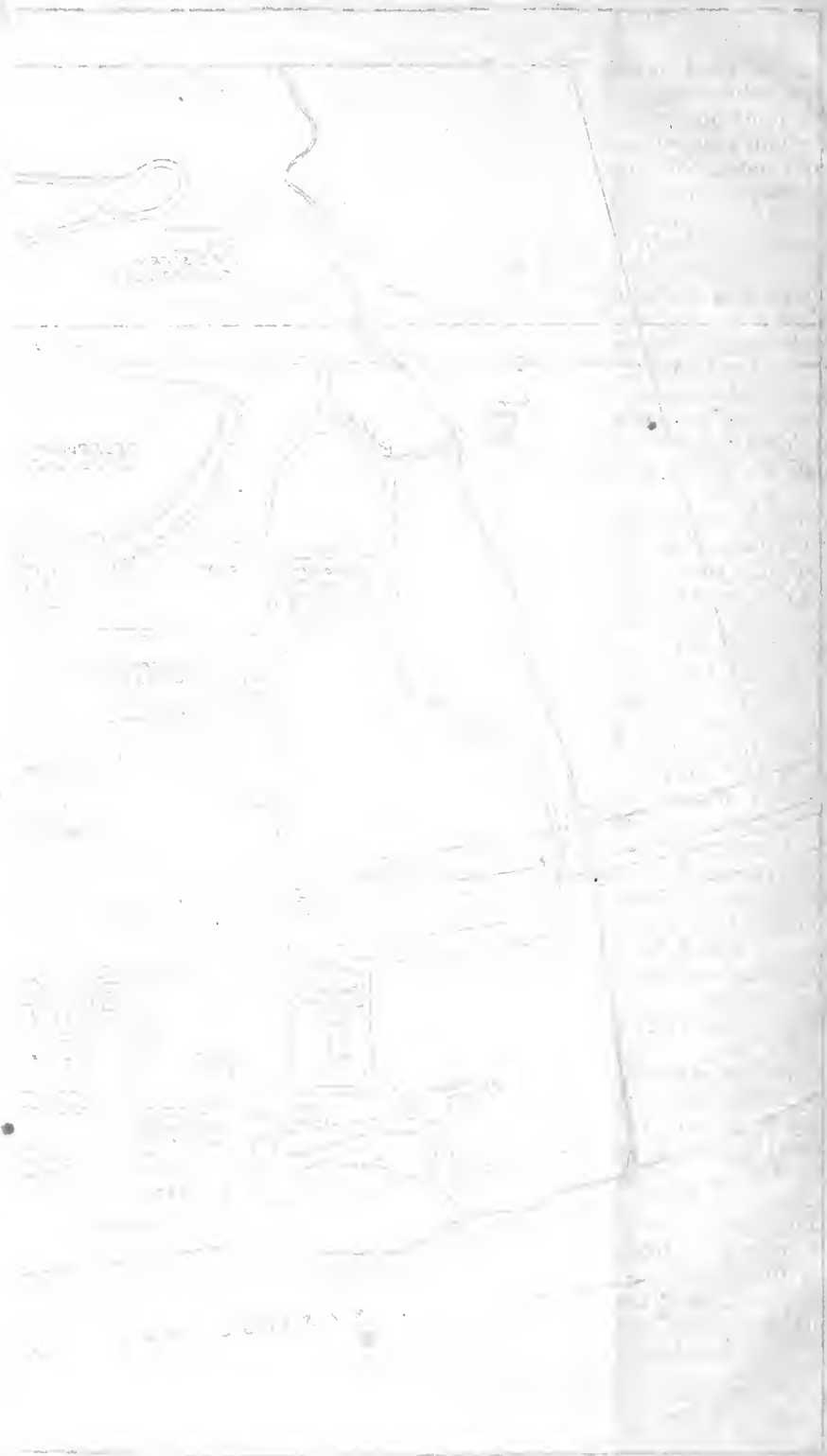
It is shown in Table 2 that the chironomid larvæ are among the most important single items of food taken by the young of the largemouth black bass during the summer. The larvæ of a certain species of the chironomids removed from the digestive tract were identifiable and later checked up with specimens taken from the ponds. These proved to be *Orthocladius nivoriundus* Fitch., a species common in the ponds and the one upon which the bass chiefly fed. The body walls of this larva are thin and transparent, and when lightly crushed under a cover glass the food content can be readily determined with the microscope. It was this identification of the alga in the crushed specimens taken from the bass that gave the clue to the chain of food relations subsequently to be described.

^a See accompanying map showing topography of the ponds under investigation.









Previous to the identification of this chironomid in the fishponds the inventory of the plants had disclosed the interesting association of the larval stage of this insect with the alga, *Mougeotia genuflexa*. The alga was exceedingly abundant and produced a most remarkable and beautiful formation. This formation, or algal mat, as it may be called, was composed of delicate, light-green filaments of gossamer-like threads which were interwoven intricately in the form of loose-meshed rolls suspended near the surface of the water. The author's attention was attracted by a large number of elliptically-shaped bags, or cases, lightly held in the meshes of the algal mat. These proved to be the larval cases of the chironomid in question. While foraging for food the larvæ move in and out of their cases, retaining their hold, meanwhile, by their caudal hooks. In feeding they draw toward them filaments from the loose meshes of *Mougeotia*, or they forage directly from the outer walls of their cases, to which this alga is applied in the construction of the case, renewing the filaments as fast as they become depleted. The larvæ continue to feed upon this alga as long as the supply lasts, which is generally only until the middle of July, for by that time this species of alga, which flourishes during the early part of the season, has passed the stage when floating mats are readily formed. Thereafter it becomes scattered through the partial disintegration or breaking up of the filaments. It is at this time that the characteristic "knees" or swellings in the cells occur which give to this form of *Mougeotia* its specific name, *genuflexa*. It is while engaged in these feeding operations that the larvæ fall prey to the bass.

Several hundred larvæ of *Orthocladus nivoriundus* were examined to determine to what extent other algæ contributed to their food supply. The determination is a simple matter. The larvæ are lightly crushed under the cover glass by a slow, forward movement of the thumb, a slight pressure being sufficient to push out the contents of the digestive tube. The material is teased out under the microscope, and the problem becomes one of identification of the algæ. Almost without exception larvæ taken from the mats of *Mougeotia* showed a forage value of 100 per cent of this alga. From larvæ taken at random in pond 3D, from habitats in which other algæ were the chief constituents and *Mougeotia* appeared only as a small factor in the heterogeneous assortment, this alga again formed the bulk of the food. Specimens of *O. nivoriundus* were hatched in a watch glass to which had been added a variety of algæ as well as *Mougeotia*, and it is interesting to note that the young selected the latter invariably. It is not surprising, for *Mougeotia* is one of the most delicate of the filamentous forms and possesses a brittleness which apparently recommends it to the larvæ, for when observed in their feeding operations they were seen to snap off filaments in one-cell and two-cell lengths with great rapidity. This preference for *Mougeotia* was observed in the very earliest stages of larval growth, and it continued to be shown to pupation.

Later broods of *Orthocladus nivoriundus*, of which there appeared to be three during the summer, found their natural forage among other algæ which succeeded *Mougeotia genuflexa*, such as *Mougeotia sphaerocarpa*, *Spirogyra nitida*, *S. majuscula*, *Cedogonium*, *Hydrodictyon reticulatum*, *Lyngbya*, and various microscopic forms present in the algal mats.

IMPORTANCE OF ALGAL MATS AS FORAGE.

The larva of the chironomid, *Orthocladius nivorius*, forms an important item in the dietary of the largemouth black bass. In turn the alga *Mougeotia* and other filamentous types supply forage for the chironomids. Thus these common pond plants contribute in a material way to the support of the bass.

Nearly all of the aforementioned algae are commonly distributed in ponds. Where they do not occur and the region is within their range, they can easily be introduced into the ponds by transferring a roll or wad of the alga before it dries out. If the alga is to be transferred by mail it should be rolled in a wet cloth, wrapped in thick paper, and dispatched at once.

Unfortunately the notion exists that algal mats serve no useful purpose, and wasteful practices prevail in the seining operations. Without discrimination they are raked out, thrown upon the bank, and left to decompose, regardless of kind or function in the economy of the pond. The author's observations thus far on the value of algal mats, which may be called locally "moss," "moss blanket," or "water moss," lead to the conclusion that discrimination must be exercised if the ponds are to be properly stocked with useful forage plants. For help in such discrimination the species which commonly produce the algal mats, or "moss," floating on the surface of ponds, are given as follows: *Cladophora crispata*, *Hydrodictyon reticulatum*, *Pithophora oedogonia* var. *vaucherioides*, *Oedogonium martenicense*, *Rhizoclonium hieroglyphicum*, and *Spirogyra* species. Generally not one form alone produces the mat or blanket but a combination, as *Cladophora* and *Pithophora*; *Hydrodictyon*, *Oedogonium*, and *Cladophora*, etc.

Blankets in which *Cladophora*, *Pithophora*, and *Rhizoclonium* are the prominent forms appear to be least desirable, though the subject warrants further investigation. This blanket complex reproduces and forms a coarse, thick mat which readily covers a pond and shuts out the light. Under control, however, this mat may be regarded as useful. It should be conserved near the edges only.

FIELD CHARACTERS OF VARIOUS ALGAL MATS.

The following field characters will assist in discriminating the different kinds of algal mats or blankets:

Mougeotia geniculata when abundant forms a loose, filmy, floating aggregation of delicate, light-green, gossamerlike threads lightly suspended near the surface of the water and easily wafted about by the wind. It is as difficult to scoop up in the hand as a floating spider web would be. This alga does not accumulate in sufficient quantity to become detrimental, since its filaments are so delicate and form so loose a mesh that light is not appreciably shut out by it.

Mougeotia sphaerocarpa is also a delicate alga, though a little less so than *M. geniculata*, and its growth habit is different. It has a light yellow-green frothy look and floats on the surface of the water as a thin film. It is found in the sheltered places usually, though it may spread over a small pond as a surface film when undisturbed by the wind. The frothy appearance is due to the very active photosynthetic capacity of the alga, the oxygen bubbles being confined,

meanwhile, in the meshes of the filaments. This alga compares favorably with *M. genuflexa* as a food producer. It appears in abundance in the ponds later in the season than the foregoing species and has been observed repeatedly in the examination of the larval food of *Orthocladus*, *Pseudochironomus*, and *Stratiomyia*.

Spirogyra species are generally a vivid green. They more often form a part of an algal complex, though they may occur nearly pure in round mats of varying size. They can be identified easily by the slimy, silky feel of the single threads or filaments. When held out of the water the single threads drip and curl up on drying. *Spirogyra weberi* may develop in a pure stand enveloped in a mass of transparent jelly.

Cedogonium martenicense often forms the upper layer on the mat of *Cladophora*. Upon aging, it fades to a pale yellowish color and acquires a soft cottony feel. Chironomids are active feeders upon it.

C. sp.^a does not form a mat but occurs as an epiphyte on the larger aquatics and on the coarser filamentous algæ. The slender naias (*Naias flexilis*) and the water-weed (*Elodea canadensis*) may become completely swathed in it by midsummer. It is an extremely small form of *Cedogonium* which in the aggregate takes on an olive-green look. It has the characteristic cottony feel. All things considered, it doubtless affords forage to a greater number of pond herbivores than any other alga of the ponds. Chironomids, snails (*Planorbis* and *Succinea*), and the blunt-nosed minnows, as indicated by their food contents, show a preference for this alga.

Pithophora cedogonia var. *vaucherioides* consists of short filaments which on aging look and feel like coarse, dark hair. It is generally to be found with *Cladophora* and in the mat-forming stage occupies the stratum beneath it or becomes interwoven with it.

Cladophora crispata forms the coarsest and thickest algal mats in our ponds. The mats, or portions of them, have a coarse, heavy look and a harsh feel. When the mat is lifted out of the water it feels tough and gives one the impression of handling wet, coarse, brown paper or coarse loosely-woven cloth.

Hydrodictyon reticulatum, or water-net, is easily distinguished when floated out on the hand by means of the characteristic four to five sided meshes. It may form in sufficient abundance to produce a heavy mat covering the surface of small ponds.

These "rough and ready" field characters should assist the uninitiated in discriminating the most common and widely distributed representatives of the mat-forming algæ of our pond waters. It is recognized of course that the microscope, together with keys and illustrations, is the only sure method of identification.

BOSMINA AND VOLVOX ASSOCIATION.

The plankton studies in pond 2D showed a conspicuous association of the small cladoceran, *Bosmina longirostris*, and the green alga, *Volvox*, species *perglobator* and *spermatotheca*. The association of these organisms, *Bosmina* and *Volvox*, is important in terms of fish food. The *Bosmina* afford a direct means of subsistence to the young bass; and the *Volvox*, through their contribution to the food supply of the *Bosmina*, an indirect one.

^a A valuable forage species unidentified to date but probably near *howardii*.

By reference to Table 2, it is seen that the young bass find in the small *Bosmina* a favorite natural food. It was selected by them from a varied and abundant zooplankton consisting of cladocerans, copepods, and rotifers. In the smallest fry examined the *Bosmina* content reached 100 per cent. For example, in the examination several specimens under the average of 12.2 mm. measured 10 mm. and 11 mm., and in all cases, the smaller the fry taken from the environment of *Volvox*, the larger the percentage of *Bosmina* in the food content, indicating that this is not only the earliest but the preferred natural food of the young bass.

It was found that *Bosmina* occupied the upper stratum of water in the open areas as well as the more sheltered weedy portions of the ponds. Their presence is indicated to the naked eye by the appearance, as it were, of a fine sprinkling of dust particles continually gyrating in the surface film of water. They occur in the greatest numbers just below the surface, and in this location they are accessible to the fry as they rise to feed.

The *Volvox* accumulated also in the upper stratum of water. The pulse of this alga coincided with that of *Bosmina*, but declined before any distinct diminution of *Bosmina* was noted. Further observational studies disclosed the direct dependence of *Bosmina* upon *Volvox* for subsistence.

Plankton catches from the upper stratum were taken repeatedly, and the feeding habits of *Bosmina* observed under the compound microscope. It was rarely possible to identify the food once taken into the digestive tract, because in most cases the mandibles grind the food particles beyond recognition. Occasionally, however, particles slip by whole, and when these could be seen through the transparent body walls the animal was lightly crushed under a cover glass to make the identification more sure. Bits of broken *cœnobium* of *Volvox* were identified, and these graded into the ground material characteristic of the digestive tract. In most cases the feeding habits were observed directly by watching the maneuvers of the living animal. *Volvox* was in the reproductive stage, and organisms with antherozoids, or sperms, were exceedingly abundant. The *Bosmina* in their feeding operations attached themselves to a bundle of ripe antherozoids, and by a rapid movement of the legs, characteristic of all cladocerans, winnowed the sperms within the body walls, from whence they were wafted into the mouth. This continued until the bundle of antherozoids was appreciably diminished, and the *Bosmina* whirled off to other feeding grounds, in which the constituents were often too small to identify as they were wafted into the body. *Volvox*, however, continued to remain a source of nutriment until its decline.

This interdependence of the organisms, *Bosmina* and *Volvox*, was observed in pond 1D also, but the plankton pulse was not manifested by so large a quantity of *Bosmina* in this pond.

SCAPHOLEBERIS AND MOUGEOTIA ASSOCIATION.

It was found that *Scapholeberis mucronata*, a larger cladoceran, succeeded the *Bosmina* in the food of the older fry, and investigation followed to determine its food relations among the algæ of the ponds.

Plankton catches showed a larger percentage of *Scapholeberis* in pond 1D than in all others. Attention was then concentrated upon this pond. Plankton studies were made from various regions in the pond to determine the specific plant habitat of the cladoceran. This proved to be the scum or film produced by the alga, *Mougeotia sphaerocarpa*, in the quieter portions of the pond. In these regions the algal complex teemed with *Scapholeberis*, the feeding grounds being conspicuously localized in the region of the *Mougeotia* filaments.

The examination of the food content in the digestive tracts of *Scapholeberis* revealed a miscellaneous diet of small unicellular and palmelloid algae which abounded in the *Mougeotia* complex. The most common forms were small diatoms, and such green algae as *Sphaerocystis*, *Oocystis*, *Celastrum*, and *Schizochlamys*.

The association of this cladoceran with the *Mougeotia* complex adds another point in favor of the introduction and cultivation of *Mougeotia* to supply a natural forage in fishponds.

The *Scapholeberis* pulse in pond 1D attained its maximum in late July and early August. At that time it supplied a fair percentage of the food of the largemouth black bass (Table 2) and a high percentage of the food of the bluegill (Table 3).

Ponds 1D and 2D have differed in the contribution they made to the food supply of the young fish in the matter of quantity as well as variety. This was particularly true of the *Bosmina* pulse which occurred in both ponds simultaneously but to a lesser degree in pond 1D. Birge and Juday (1911) state: "The answer to the question of why different bodies of water differ so widely in productivity is wholly beyond our knowledge." In these ponds, however, a partial explanation may be sought in the difference in kind and quantity of living plants as well as in the accumulations of debris during succeeding seasons.

In physical features the ponds are similar. They are equally deep, and they are surrounded by a similar vegetation. They have been treated alike, that is, they have been wintered full, not dry. Such draining as has been necessary to conduct the seining operations has been temporary only. Physiologically, however, they are more or less distinct because of the dissimilar character of the vegetation in them. Pond 1D has been richly stocked with floating algae which at times have covered the surface. Few of the larger rooted aquatics are present. Pond 2D has no algal mats or blankets, but fully one-tenth of the surface area has been covered by the large-rooted aquatic, *Potamogeton illinoensis*, interspersed in places with the nonrooted *Ceratophyllum*, or hornwort. In these ponds are present, apparently, the requisite conditions to produce a conspicuous plankton pulse of great economic value in terms of the natural forage of fish fry by supplying in quantity organisms which are preferred by the fry during the early days of feeding.

DAPHNIA AND APHANIZOMENON ASSOCIATION.

Data in the tables show that a high percentage of food is supplied by the daphnids. They are recognized herbivores in the ponds, and it remains to explain their particular plant preferences and associations.

A remarkable illustration of such an association was presented during the present season in the studies connected with pond 9D, in which *Daphnia pulex*, one of the largest of the daphnids, was produced in enormous quantity by natural means. The blue-green alga, *Aphanizomenon flos-aquæ*, contributed directly to its support and proved to be the most desirable food of a heavy, natural culture of *Daphnia pulex*.

The author's first observation of this association in the pond occurred on June 21, 1918. At this time a "bloom" of the *Aphanizomenon* was approaching its maximum. It was so abundant that the water appeared blue-green and oily. A few hand strokes of the dip net would bring up a quart of it in concentrated form. The individual colonies are ordinarily microscopic, but during the acceleration of growth in "bloom" production the colonies are considerably augmented and become readily distinguishable. They appear as flocculent masses, 7 to 16 mm. long and less than half as wide. They are delicate and tissuelike and assume the form of flattened spindle-shaped masses lightly suspended in the water at all depths, from the surface to the bottom of the pond. Practically a pure stand had developed, for there were few representatives of other floating algae present. The station records noted the presence of the algae in May. From that time until June 21, the date of the author's first observation, multiplication must have taken place with great rapidity, and it continued to do so until the maximum was reached in the interval of July 24 to 30, when the algae could be rolled up from the bottom like mush.

This conspicuous growth of algae in the pond was attended by one equally remarkable in the number of *Daphnia* produced. The *Daphnia* swarmed among the algae, forming practically a pure culture of *Daphnia pulex*. A rough estimate by volume, obtained by the gravity method, showed approximately 75 cc. per cubic meter. Accurate determinations were difficult because of the accompanying algal debris in the concentrations. When the algal maximum was attained the *Daphnia* pulse had already begun to decline. Cypris, copepods, and rotifers increased in the zooplankton and *Clathrocystis*, *Volvox*, and *Pleodorina* in the phytoplankton.

The daphnids fed continuously upon the *Aphanizomenon*. The entire process of feeding could be observed easily by placing them in a watch glass or in a hollow glass slide and observing them with the compound microscope. The flocculent masses of the alga were wafted into the open walls of the body and fed forward toward the mouth by the action of the legs in the manner so aptly described by Birge (1918). During the feeding operations the *Daphnia* were offered a mixed plankton, but invariably they retained only the *Aphanizomenon* in the food current streaming toward the mouth. Observations on the feeding habits were continued from time to time during a period of five weeks, and it was easily seen that the abundant natural forage provided in *Aphanizomenon* was one of the determining factors in the high productivity of *Daphnia pulex*.

By reference to Tables 4 and 5 it is seen that *Daphnia* formed a high percentage of the food content in the orange-spotted sunfish and catfish with which the pond was stocked. Data are not at hand for the very young catfish since it was desirable not to disturb the ponds

by seining during the breeding period, but the large size of the fingerlings (Table 5) at the date recorded seems worthy of note and readily explainable in terms of an abundance of desirable natural food.

The succession of causes, physical and physiological, which have led to the remarkable acceleration of growth in the alga, *Aphanizomenon*, and the accompanying culture of daphnids is not easy to explain; yet it is desirable to record the method of treatment of the pond which has produced this extraordinary development. The pond covers an area of 0.66 acre and is free from floating plants. In the shallow portions there are submerged aquatics such as Naias and *Potamogeton pusillus*; and around the edge, a little of the blanket-forming alga, *Cladophora crispata*. In general it is an open pond free from the larger aquatics or their accumulations. It could easily have become "seeded down" by spores of *Aphanizomenon* through inlet waters from the supply reservoir which in turn receives the river water. This alga is common in the supply waters and is distributed in season to the ponds. *Daphnia pulex* are also common in the ponds. A contributing cause of the great "wave" of *Daphnia* is possibly due to the fact that the pond has been wintered dry during successive seasons, the freezing and drying processes affecting the winter eggs of the daphnids beneficially.

MAYFLIES IN THE FOOD OF BASS.

Reference to Table 2 indicates the importance of mayfly larvæ in the food of the young largemouth black bass. The mayflies are herbivores. The researches of Needham (1905), Morgan (1913), and Clemens (1917), on the life histories of these insects have shown that they subsist on a variety of plants in our lakes and streams, the familiar articles of diet being diatoms, unicellular and filamentous algæ, and the larger aquatic plants, the latter generally in a partial state of disorganization. Unfortunately, time has not permitted investigation of the plant associations of this group of insects in small ponds. From the few records of examination, however, it may be forecasted that an important habitat preference of some species of the larvæ is among the larger potamogetons.

THE DIRECT FUNCTION OF PLANTS IN FISHPONDS.

The tables show a forage value of plants which can not be regarded as merely accidental. By reference to Table 7 it becomes evident that the young of the buffalofish favor an admixture of animal and plant substance. The absence of grit in the digestive tract and the presence of plant materials, such as the staminate flowers of *Elodea*, for example, which are found only at or near the surface of the ponds, illustrate the wide range of their feeding habits. The high percentage in the food content of the flagellate plants, *Pandorina*, *Eudorina*, and *Pleodorina*, is suggestive of the value of the small things among the pond plants.

The most conspicuous function of plants in the fishpond is found in their indirect relations, in their contribution to the forage of myriads of animal forms upon which fish feed. This paper has emphasized this function of plants in its consideration of animal-

plant associations, and it is through a more complete understanding of such associations that the method of rationing the ponds to increase their productivity by natural means can be approached.

SUMMARY.

1. Chironomid larvæ are among the most important single items in the dietary of young bass.

2. The identification of the food content and plant associations of the chironomids indicates the importance of cultivating certain algal forms in the ponds to provide adequate forage requirements.

3. Mat-forming algæ of certain types provide valuable forage areas for chironomids and cladocerans.

4. The *Bosmina-Volvox* association is of special importance in providing the first forage materials for the bass fry and the young bluegill.

5. The *Scapholeberis-Mougeotia* association is important in providing a later food for the advanced fry stage.

6. The *Daphnia-Aphanizomenon* association develops a heavy culture of daphnia.

7. Plants are of importance directly in supplying a high percentage of food to the advanced fry of the buffalofish.

8. The blunt-nosed minnow in a pond habitat subsists mainly upon plants.

9. The rationing of ponds for a continuous and abundant supply of natural forage must depend upon a more precise knowledge of the animal and plant associations.

TABLES.

[NOTE.—All figures in the tables referring to food content represent volumetric percentage estimates. Measurements in lengths are given in millimeters and exclude the caudal fin.]

TABLE 1.—INVENTORY OF AQUATIC PLANTS IN CERTAIN PONDS OF SERIES B AND D, FAIRPORT, IOWA.^a

[P means present; A means present in abundance.]

Aquatic plants.	June, 1917.					June, 1918.
	Pond 1D.	Pond 2D.	Pond 3D.	Pond 8D.	Pond 16B.	Pond 9D.
Flagellates: <i>Euglena sanguinea</i>		P			P	P
Blue-green algae:						
<i>Aphanizomenon flos-aquæ</i>			P	P	P	A
<i>Microcystis</i>				P		A
<i>Clathrocystis</i>		P	P	P		
<i>Celosphaerium</i>				P		
<i>Merismopedium</i>			P			
<i>Oscillatoria</i>	P					
<i>Lynghya martensiana</i>				P		
<i>Anabaena circinalis</i>		A			P	P
<i>Anabaena flos-aquæ</i>			P	P	P	P
<i>Rivularia natans</i>						
Diatoms:						
<i>Navicula</i>	A	P	P	P	P	P
<i>Synedra</i>	P	P	P	P	P	A
<i>Pleurosigma</i>		P	A	A		A
<i>Cocconeis</i>	P	P		A	P	P
<i>Melosira</i>		A				
<i>Tabellaria fenestrata</i>	A	P	P			
<i>Fragilaria</i>		A				
<i>Gomphonema</i>						
<i>Amphora</i>	P					

^a Inventory not exhaustive but sufficiently detailed to serve as a working basis.

TABLE 1.—INVENTORY OF AQUATIC PLANTS IN CERTAIN PONDS OF SERIES B AND D, FAIRPORT, IOWA—Continued.

Aquatic plants.	June, 1917.					June, 1918.
	Pond 1D.	Pond 2D.	Pond 3D.	Pond 8D.	Pond 16B.	Pond 9D.
Green algæ:						
Cosmarium pyramidatum.....	P		P	P	P	A
C. undulatum.....	P	P	P	P	P	P
C. notabile.....						P
Closterium moniliferum.....	P		P	P		
C. lanceolatum.....			P	P	A	A
C. lunula.....				P		
Staurostrum polymorphum.....		P	P	P	P	P
Selastrum.....		P			P	
Zygnema sp.....		P	P			
Spirogyra communis.....	P	P	P			
S. porticallis.....		P	P			
S. varians.....			A	P		
S. decima.....						
S. nitida.....	P	P				
S. crassa.....	A	P	A		P	
S. tenuissima.....	P	P	A			
S. gravilleana.....				P		
Mougeotia genulifera.....			A			
M. lætevirens.....			A			
M. sphaerocarpa.....	A					
Chlamydomonas.....				P		
Pandorina morum.....		P		P	A	P
Pleodorina californica.....				A	A	P
Eudorina elegans.....	P	P	P	P	P	
Volvox perlobator.....		P	P	P	P	P
Volvox spermatosphæra.....						
Palmella.....		P	P			
Botryococcus.....			P			
Ineffigiata.....				P		
Tetraspora.....		P				
Anchistrodesmus.....		P				
Scenedesmus.....		P		P		P
Hydrodictyon reticulatum.....			P	A		
Pediastrum duplex.....	P	P	P	P	P	
Ulothrix.....			P		P	
Cedogonium rivulare.....	A	A		P		
Ce. sp.....	A	A	A			A
Ce. martenicense.....	A		P			
Cladophora crispata.....	A	P	A		P	P
Rhizoclonium hieroglyphicum.....			A			
Pithophora cedogonium var. vaucherioides.....	A	P	A			P
Chara.....			P			
Flowering plants:						
Typha latifolia.....	P	P	P	P		P
Sparganium americanum.....	P	P				
Potamogeton illinoensis.....		A	P			
P. pectinatus.....			P		A	
P. pusillus.....			A	P		P
Najas flexilis.....	P	A	A	A		A
Sagittaria latifolia.....		P	P	P	P	
Elodea canadensis.....	P	A	A	A		P
Vallisneria spiralis.....		P	P			
Lemna minor.....	P			P		
Heteranthera dubia.....			A		P	
Ceratophyllum demersum.....	P	A				
Nymphaea advena.....					P	
Castalia odorata.....			A		P	
Ranunculus aquatilis.....	A	A	A			
Myriophyllum spicatum.....			P			

TABLE 2.—FOOD CONTENT OF LARGEMOUTH BLACK BASS (*MICROPTERUS SALMOIDES*), ADVANCED FRY AND FINGERLINGS, IN CERTAIN PONDS AT FAIRPORT, IOWA.

Date.	Pond.	Specimens.	Average length.	Animals.								
				Cladocerans.			Cypris.	Copepods.	Nauplii.	Rotifers.	Chironomid larvæ. ^c	Chironomid adults.
				Bosmina. ^a	Scapholeberis. ^b	Miscellaneous forms.						
1917.		No.	Mm.									
June 28.....	3D	e 3	20								97.3	
1918.												
July 5.....	3D	2	31		5	25		5			42	
July 11.....	3D	5	31.5			63.5	4				10	
July 18.....	2D	16	12.2	60	6	13.3		1.2	3.1	1.2	16.8	0.9
Do.....	3D	6	33			7.1		2.5			18.3	
July 25.....	1D	5	42.7		6.2		6	2			33.4	
Do.....	2D	3	31	13.3		8.3		35			16.7	
Do.....	3D	15	36.9			26	.1	.7			15.4	
Aug. 4.....	3D	5	41.5			6					30	
Aug. 8.....	3D	4	43			12.5		10			67.5	
Aug. 10.....	3D	5	43.2			16	3	6			18	

Date.	Animals—Continued.								Plants.				
	Beetle larvæ. ^d	Mayfly larvæ.	Damselfly larvæ.	Dragonfly larvæ.	Adult flies.	Water mites.	Caddice larvæ.	Unidentified material.	Various unicellular algæ.	Volvox.	Edogonium sp.	Pithophora.	Naias flexilis.
1917.													
June 28.....								2.5					
1918.													
July 5.....		20						2.5					
July 11.....	5	8				5							
July 18.....		1.2							1.2				
Do.....		4.2	2.5	5	4.2			56					
July 25.....	5	16.4	12	19									
Do.....					26.7					3.3			
Do.....	44.3	4.8	6					.6					1.6
Aug. 4.....	25	30						7					
Aug. 8.....	10												
Aug. 10.....	2	28					14				2	8	3

^a Bosmina and Volvox association.^b Scapholeberis and Mougéotia association.^c Chiefly Orthocladus and Cricotopus sp., Tanypus decoloratus Mall, and Pseudochironomus richardsoni Mall. The identifications of chironomids were made by Dr. R. A. Mulkowski and Dr. O. A. Johannsen.^d Mainly Dytiscid beetles.^e From H. F. Schradieck's unpublished reports. The larvæ in the food content were identified as Orthocladus nivoriundus. The algæ upon which these chironomids had fed consisted of 100 per cent Mougéotia genuflexa.

TABLE 3.—FOOD CONTENT OF BLUEGILL (*LEPOMIS PALLIDUS*), ADVANCED FRY AND FINGERLINGS, IN CERTAIN PONDS AT FAIRPORT, IOWA.

Date.	Pond.	Specimens.	Average length.	Animals.									
				Cladocerans.			Adult copepods.	Nauplii.	Cypris.	Chironomid larvæ. ^a	Damselfly larvæ.	Mayfly larvæ.	
				Bosmina.	Scapholeberis mucronata.	Miscellaneous forms.							
1918.		No.	Mm.										
July 25.....	2D.....	10	12.4	66.9	.....	11.1	.....	10	.....	11	.....	.....	.....
Do.....	1D.....	18	18.9	9.4	17.2	28.4	31.1	.....	0.6	9.2	.....	.....	.....
Aug. 1.....	2D.....	25	13.4	43.6	.....	19	9	6.1	.8	13.8	.....	.....	.....
Do.....	2D.....	17	15.6	49.9	.....	12.4	12.4	.....	.6	15.2	.....	.....	.....
Aug. 8.....	1D.....	5	36.9	4.5	.....	52	12.6	.....	4	11	.....	2	5

Date.	Animals—Contd.				Plants.								
	Beetle larvæ.	Water mites.	Rhizopods.	Unidentified.	Unicellular algæ.	Anabaena.	Diatoms.	Volvex.	Desmids.	Mougeotia.	Spirogyra.	Cedogonium.	Spores.
1918.													
July 25.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....
Do.....	1.4	.....	.....	.....	.....	0.3	.....	.....	.....	1.3	0.3	0.3	.....
Aug. 1.....	.....	0.6	.....	0.8	0.4	.....	0.3	4.4	.....	5	6	.....	.....
Do.....	.....	.....	.....	3.2	.....	.....	1.4	.....	0.6	.....	.....	1.2	2.9
Aug. 8.....	.....	2	.....	3	.....	.....	.....	.....	1	.....	.....	3	.....

^a Chiefly *Tanytus decoloratus* Mall and *Pseudochironomus richardsoni* Mall.TABLE 4.—FOOD CONTENT OF ORANGE-SPOTTED SUNFISH (*LEPOMIS HUMILIS*), ADVANCED FRY AND FINGERLINGS, IN POND 9D, FAIRPORT, IOWA.

Date.	Specimens.	Average length.	Animals.											Plants.	
			Cladocerans.			Diaptomus.	Miscellaneous copepods.	Cypris.	Chironomid larvæ.	Notonectids.	Beetle larvæ.	Unidentified.	Hyalella.	Cedogonium sp.	Plant débris.
			Daphnia pulex. ^a	Chydorus.	Miscellaneous forms.										
1918.	No.	Mm.													
July 15.....	2	30.5	19.5	.....	.....	.....	.....	.....	80.5	.....	.....	.....	.....	.....	.....
Do.....	1	71	10	.....	.....	.....	.....	10	30	.....	50	.....	.....	.....	.....
July 18.....	5	18.6	39	.....	6	9	15	.....	25	.....	6	.....	.....	.....	.....
July 25.....	12	25.6	31.9	18.4	8	12	19.5	9	16.1	.....	.....	.....	.....	.....	.....
July 26.....	16	22.5	52	6	1.5	9	27.3	.....	6.5	3.1	.....	0.6	0.9	0.6	.....
Aug. 2.....	19	23.3	27.1	20.4	.....	18.4	25.6	.....	4.2	.....	4.2	.....	.....	.....	.....
Aug. 8.....	10	42.5	6	5.1	.....	3	14.5	12	57.5	.....	.....	4	.....	.....	2

^a *Daphnia* and *Aphanizomenon* association.

TABLE 5.—FOOD CONTENT OF CHANNEL-CAT (*ICTALURUS PUNCTATUS*), FINGER-LINGS, IN POND 9D, FAIRPORT, IOWA.

Date.	Specimens.	Average length.	Animals.						
			Daphnids.	Chydorus.	Copepods.	Cypris.	Chironomid larvae and pupae.	Damselfly larvae.	Notonectids.
July 25, 1918.	No. 2	Mm. 51.5	37.5	.....	20	2.5	30	.....	7.5
Aug. 2.	6	54.1	3.3	13.5	2.5	2.5	28.3	3.3	2.3
Aug. 16.	6	58.3	4.2	17.5	5.3	2.2	58.3	.....	.....

Date.	Animals—Contd.			Plants.					
	Hyalella.	Leeches.	Grit, debris, etc.	Clathrocystis.	Diatoms.	Volvox.	Closterium sp. Cosmarium sp.	Cedogonium sp.	Elodea.
July 25, 1918.	.....	.....	.....	.....	.....	.....	.....	.....	.....
Aug. 2.	7.5	15.8	12.5	.....	.....	1.2	.....	1.66	.....
Aug. 16.	.....	.....	5.8	3.3	0.83	.....	1.7	.....	0.33

TABLE 6.—FOOD CONTENT OF BLUNT-NOSED MINNOW (*PIMEPHALES NOTATUS*) IN CERTAIN PONDS AT FAIRPORT, IOWA.

Date.	Pond.	Specimens.	Average length.	Animals.						Plants.	
				Daphnids.	Chironomid larvae.	Anurea cochlearis.	Statoblasts of pectinella.	Insect debris.	Grit.	Phacus.	Euglena.
July 26, 1918.	9D	No. 1	Mm. 49	5	.....	.....	.....	.....	.....	.....	.....
Aug. 7.	9D	2	46.5	.....	.....	17.5	7.5	.....	47.5	.....	.....
Aug. 8.	8D	9	45.1	6.7	.....	4.4	.55	1.1	4.4	3.9	.....
Aug. 15.	8D	4	46.2	1.3	5	.....	.....	.....	27.5	1.75	0.75

Date.	Plants—Continued.									
	Chroococcus.	Oscillatoria.	Lyngbya.	Anabena.	Spirulina.	Diatoms.	Schizochlamys.	Closterium sp. Cosmarium sp.	Cedogonium sp.	Natas flexilis.
July 26, 1918.	.....	.....	.....	.....	.....	5	.....	10	80	.....
Aug. 7.	.....	.....	.....	2.5	.....	.....	5	20	.....	.....
Aug. 8.	4.4	1.1	28.9	6.7	7.2	3.3	5	2.8	.....	3.3
Aug. 15.	.....	.....	55	.....	5	1.25	.....	2.5	.....	15.5

TABLE 7.—FOOD CONTENT OF BUFFALOFISH (*ICTIOBUS BUBILUS* AND *I. CYPRINELLA*), ADVANCED FRY AND FINGERLINGS, IN POND 16B, FAIRPORT, IOWA.^a

Date.	Specimens.	Average length.	Animals.							Plants.		
			Arcella.	Diifugia.	Cladocerans.	Rotifers.	Statoblasts of Plumatella.	Insect eggs.	Chironomid larvae.	Blue-green algae.	Ceratum.	Diatoms.
1917.	No.	Mm.										
July 12.....	7	12	.....	.....	5	20.2	.....	.....	1.2	0.6	.....	5.5
July 24.....	20	19.9	3.1	15.2	.....	3.3	.....	1.3	3.1	3.1	.....	3.3
Aug. 24.....	15	29.6	6.2	25.8	6.8	12.2	0.1	.....	1.1	6.4	2	3.2

Date.	Plants—Continued.									
	Euglena.	Volvox.	Pleodorina.	Eudorina.	Pandorina.	Pediastrum.	Scenedesmus.	Desmids.	Chlorella sp.	Staminate fls. of Elodea.
1917.										
July 12.....	7.1	.....	5.1	15.4	30.6	1	.....	8	0.1	.....
July 24.....	.1	.....	15	2	3	.....	.....	4.2	1.5	19.8
Aug. 24.....		0.1	31.3				0.1	2.8	.2	.3

^a Fry hatched in jars May 17 to 22, 1917, and transferred to pond May 25, 1917.

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